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LETTERS TO THE EDITOR

Synthesis of Ethyl Polychlorocyclopropanoates

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We have earlier shown [1] that alkylation of diethyl malonate with chloromethyl-*gem*-dichlorocyclopropanes affords cyclopropylmalonates **1a–1c** with high selectivity. Extending this study, we used compounds **1a**–**1c** to obtain ethyl polychlorocyclopropanoates **2a–2c** which are of interest for creation of bioactive materials [2].

Decarboxylation of malonates **1a**–**1c** was performed via a known method [3] in the presence of lithium chloride in DMSO medium at 140°C. The yield of desired products **2a**–**2c** was 80–90% (Scheme 1).

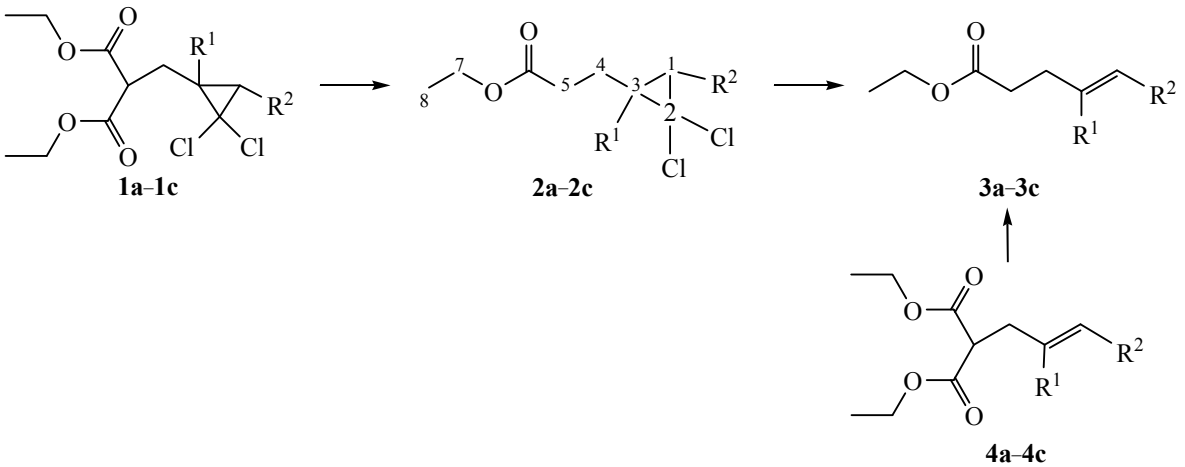
Authentic synthesis of compounds **2a**–**2c** was based on dichlorocarbenation of ethyl esters **3a**–**3c** obtained via decarboxylation of the corresponding alkenylmalonates **4a–4c** [4].

Comparison of two synthesis approaches showed that the decarboxylation of polychlorocyclopropane-containing malonates **1a–1c** was advantageous for obtaining esters **2a–2c**.

Note that the studied conversion of *trans*-1,3-dichloropropene derivatives **1c** and **3c** proceeded with preservation of the *trans*-configuration. That was indicated by the presence of a doublet signal of C^3H proton of cyclopropane ring at 3.20 ppm (^3J = 6.2 Hz) in the spectrum of compound **2c**, whereas the same proton signal of *cis*-isomer is observed in weak field (3.57 ppm, ^3J = 8.0 Hz) [5]. It is known [5] that the C^2H proton *trans*-positioned to electronegative substituent resonates in stronger field than that in *cis*-isomer.

The ^{13}C NMR spectrum of compound **2c** contained the signal of C^3 carbon atom at 44.96 ppm, typical of *trans*-substituted cyclopropanes, while in *cis*-isomer this atom resonates in strong field (34.45 ppm) [5].

Scheme 1.



R^1 = H (**1a**, **1c**, **2a**, **2c**, **3a**, **3c**, **4a**, **4c**), CH_3 (**1b**, **2b**, **3b**, **4b**); R^2 = H (**1a**, **1b**, **2a**, **2b**, **3a**, **3b**, **4a**, **4b**), Cl (**1c**, **2c**, **3c**, **4c**).

The starting cyclopropylmalonates **1a–1c** were prepared via *C*-alkylation of diethyl malonate with the corresponding chloroalkenes as described in [1].

Synthesis of polychlorocyclopropanoic acids esters (2a–2c). *a. Decarboxylation of cyclopropylmalonates **1a–1c**.* A mixture of 0.01 mol of the corresponding malonate **1**, 0.03 mol (1.26 g) of lithium chloride, 0.02 mol of (0.36 g) of water, and 10 mL of DMSO was stirred at 140°C for 8 h. Upon completion of the reaction (monitoring by GLC), the mixture was cooled to room temperature, washed with water, and extracted with chloroform. The organic layer was dried over sodium sulfate and evaporated. The residue was distilled in vacuum.

*b. Dichlorocarbenation of compounds **3a–3c**.* A mixture of 0.01 mol of the corresponding ester **3**, 30 mL of chloroform, 32 g of 50% NaOH solution, and 0.001 mol (0.23 g) of triethylbenzylammonium chloride was stirred at 55°C for 4–11 h until the conversion of the substrate was complete. After that, the mixture was washed with water to neutral reaction. The organic layer was dried over calcium chloride and evaporated. The residue was subject to chromato-graphy on silica gel eluting with a 9 : 1 hexane–diethyl ether mixture.

Ethyl 3-(2,2-dichlorocyclopropyl)propanoate (2a). Yield 80% (*a*) 59% (*b*), bp 120°C (9 mmHg), R_f 0.51. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.15 t (1H, C^8H_3, ^3J = 6.8), 1.30–1.35 m (1H, C^3H), 1.60–1.65 m (2H, C^1H_a, C^1H_b) 1.85–1.90 m (2H, C^4H_a, C^4H_b), 2.50–2.55 m (2H, C^5H_a, C^5H_b), 4.00 q (2H, C^7H_2, ^3J = 7.1). ^{13}C NMR spectrum, δ_C, ppm: 14.23 (C^8H_3), 25.77 (C^4H_2), 26.70 (C^1H_2), 29.88 (C^5H_2), 33.03 (C^3H), 60.52 (C^7H_2), 60.98 (C^2Cl_2), 172.22 (C^6=O). Mass spectrum, *m*/*e* (I_{rel}, %): 211 (<1) $[M]^{\cdot+}$, 164 (54), 166 (23), 168 (10), 136 (23), 138 (10), 140 (6), 122 (60), 124 (23), 126 (16), 111 (41), 113 (20), 115 (7), 88 (100), 90 (21), 92 (5).

Ethyl 3-(2,2-dichloro-1-methylcyclopropyl)propanoate (2b). Yield 90% (*a*), 62% (*b*), bp 123°C (9 mmHg), R_f 0.50. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.10 t (3H, C^8H_3, ^3J = 6.9), 1.30 s (3H, C^9H_3), 1.95–2.10 m (2H, C^4H_a, C^4H_b), 2.50–2.55 m (2H, C^5H_a, C^5H_b), 4.10 q (2H, C^7H_a, C^7H_b, ^3J = 7.2). ^{13}C NMR spectrum, δ_C, ppm: 14.20 (C^8H_3), 19.53 (C^9H_3), 29.35 (C^5H_2), 30.40 (C^4H_2), 31.92 (C^1H_2), 35.10 (C^3), 60.50 (C^7H_2), 65.50 (C^2Cl_2), 172.64 (C^6=O). Mass spectrum, *m*/*e* (I_{rel}, %): 225 (<1) $[M]^{\cdot+}$, 189 (36), 191 (13), (193) (5), 141(55), 143 (21), 145 (5), 125 (21), 115 (60), 117 (24), 119 (3), 99 (40), 101 (15), 103 (2).

Ethyl 3-(2,2,3-trichlorocyclopropyl)propanoate (2c). Yield 45% (*a*), 35% (*b*), bp 130°C (4 mmHg), R_f 0.52. ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.30 t (3H, C^8H_3, ^3J = 7.0), 1.75–1.80 m (1H, C^3H), 1.85–1.95 m (2H, C^4H_a, C^4H_b), 2.40–2.55 m (2H, C^5H_a, C^5H_b), 3.20 d (1H, C^3H, ^3J = 6.2), 4.75 q (2H, C^7H_a, C^7H_b, ^3J = 7.2). ^{13}C NMR spectrum, δ_C, ppm: 14.21 (C^8H_3,), 24.42 (C^4H_2), 32.27 (C^5H_2), 39.01 (C^3H), 44.96 (C^1H), 60.79 (C^7H_2), 63.40 (C^2Cl_2), 172.22 (C^3=O). Mass spectrum, *m*/*e* (I_{rel}, %): 245 (<1) $[M]^{\cdot+}$, 209 (78), 211 (45), 213 (8), 181 (40), 183 (15), 185 (3), 163 (9), 165 (6), 167 (1), 135 (100), 137 (30), 139 (11), 99 (31), 101 (9), 103 (4).

Synthesis of compounds 3a–3c. A mixture of 0.01 mol of the corresponding malonate **4**, 0.03 mol (1.26 g) of lithium chloride, 0.02 mol (0.36 g) of water, and 10 mL of DMSO was stirred at 130 (**3a**) or 140°C for 4–8 h. After the reaction was complete (monitoring by GC), the reaction mixture was cooled to room temperature, washed with water, and extracted with chloroform. The organic layer was dried over sodium sulfate and evaporated. The residue was distilled in vacuum.

Ethyl pent-4-enoate (3a). Yield 90%, bp 120°C (760 mmHg). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.20 t (3H, C^7H_3, ^3J = 7.1), 2.35 m (4H, C^2H_2, C^3H_2), 4.15 q (2H, C^6H_2, ^3J = 7.1) 5.05–5.10 m (2H, C^5H_2), 5.85–5.90 m (1H, C^4H). ^{13}C NMR spectrum, δ_C, ppm: 14.35 (C^7H_3), 29.31 (C^3H_2), 34.64 (C^2H_2), 60.05 (C^6H_2), 115.39 (C^5H_2), 137.98 (C^4H), 172.10 (C^1=O). Mass spectrum, *m*/*e* (I_{rel}, %): 128 (10) $[M]^{\cdot+}$, 100 (5), 83 (30), 56 (27), 55 (100).

Ethyl 4-methylpent-4-enoate (3b). Yield 80%, bp 93°C (40 mmHg). ^{1}H NMR spectrum, δ, ppm (*J*, Hz): 1.25 t (3H, C^7H_3, ^3J = 7.1), 1.72 s (3H, C^8H_3), 2.30 d (2H, C^2H_2, ^3J = 8.6), 2.40 d (2H, C^3H_2, ^3J = 8.6), 4.00 q (2H, C^6H_2, ^3J = 7.2), 5.75–5.80 m (2H, C^5H_2). ^{13}C NMR spectrum, δ_C, ppm: 14.21 (C^7H_3), 22.47 (C^8H_3), 32.66 (C^2H_2, C^3H_2), 60.29 (C^6H_2), 110.31 (C^5H_2), 144.13 (C^4), 173.28 (C^1=O). Mass spectrum, *m*/*e* (I_{rel}, %): 143 (<2) $[M]^{\cdot+}$, 118 (34), 93 (100), 89 (39), 51 (31).

Ethyl (2*E*)-5-chloroprop-4-enoate (3c). Yield 82%, bp 81°C (40 mmHg). ^{1}H NMR spectrum, δ, ppm

(J, Hz): 1.25 t (3H, C^7H_3, ^3J = 7.1), 2.35–2.60 m (4H, C^2H_2, C^3H_2), 4.15 q (2H, C^6H_2, ^3J = 7.2), 5.85–6.10 m (2H, C^5H, C^4H). ^{13}C NMR spectrum, δ_C, ppm: 14.24 (C^7H_3), 26.23 (C^3H_2), 33.51 (C^2H_2), 60.56 (C^6H_2), 118.43 (C^5H), 131.81 (C^4H), 172.41 (C^1=O). Mass spectrum, m/e (I_{rel}, %): 127 (<2) $[M]^{\cdot+}$, 117 (34), 119 (12), 99 (100), 89 (39), 53 (31).

Chromatographic analyzes were performed using a HRGS 5300 Mega Series Carlo Erba chromatograph equipped with a flame ionization detector (carrier gas helium, flow rate 30 mL min^{-1}, column length 25 m, temperature range 50–280°C with a programmed heating at 8 deg min^{-1}, detector temperature 250°C, and evaporator temperature 300°C). Chromatography–mass spectra were recorded using a Fisons (capillary column DB 560) and Focus instruments equipped with a Finnigan DSQ II mass spectrometry detector (ion source temperature 200°C, direct injection temperature 50–270°C, heating rate 10 deg min^{-1}, column Thermo TR-5MS, 50 × 2.5 × 10^{-4} m, helium flow rate – 0.7 mL/min). Mass spectra were registered in electron impact ionization mode. NMR spectra were recorded using a Bruker AVANCE-400 (400.13 MHz) spectrometer in $CDCl_3$.

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